

Effects of Time of Weed Removal and Cropping system on Weed Control and Crop Performance in Okra/Amaranthus Intercrop

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ABSTRACT

A field trial was conducted during the late wet seasons of 2011 and 2012 at the Research Farm of the Federal University of Agriculture, Alabata, Abeokuta (7°15'N, 3°25'E) in the forest savanna- transition zone of Ogun State, South Western Nigeria. The objective was to evaluate the effect of time of weed removal and **cropping system** on weed control and crop performance in okra/amaranthus intercrop. The experiment was laid out in a Randomized Complete Block Design (RCBD) in a Split- plot arrangement. The treatments consisted of three main plots and five sub plots replicated three times. The main plot treatments were **single hoe- weeding at 3 weeks after planting (WAP)**, **double weeding at 3 & 6 WAP** and no weeding, while the sub plots consisted of okra intercropped with amaranthus at **0.5 g/ m²** or **1.0 g/m²**, okra sole and amaranthus sole at **0.5 g/m²** or **1.0 g/m²**. Results from the study showed that intercropping of okra with amaranthus reduced weed infestation significantly ($p<0.05$) compared to sole okra. Weed control treatments significantly ($p<0.05$) reduced weed infestation in the intercrop while **cropping system** did not have any significant effect ($p<0.05$) on the weed biomass, plant height, pod length, number of pods and pod fresh weight. Uncontrolled weed infestation led to **50.7 %** yield loss in okra. It is therefore concluded that intercropping of okra with amaranthus is an effective means of reducing weed pressure in okra production as well as increasing land productivity.

Key words: Intercropping, weed removal, **cropping system**, amaranthus, okra

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1. INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) which is also known as Lady's finger is one of the most important vegetable crop of the tropical and sub-tropical regions of the world (1). Okra is a popular health food due to its high fibre, vitamin C and folate content (2). It is also known to be high in antioxidants, calcium and potassium (3). Okra, because of its growth habit and importance in the diets of most Africans, is often intercropped with staple food crops such as **yam, cassava, maize**, green amaranth in most agricultural zones of sub-saharan Africa (4,5).

Intercropping is the most popular cropping system in subsistence agriculture (6). Through more efficient use of water, nutrient and solar energy intercropping can significantly enhance crop productivity compared to the growth of sole crops (7). It provides more profit through enhanced utilization of soil

nutrients and space and reduces risk of crop failures due to weed, diseases and pest infestation. Intercropping also ensures efficient utilization of light and other resource, reduces soil erosion, suppresses weed growth and thereby helps to maintain greater stability in crop yield (8). A number of studies have shown that increased crop density would decrease the magnitude of effect of weed competition with crops (9, 10, 11, 12, 13,). Increase crop density has the advantage of shading weeds and better competitive advantage in crop production.

Weeds are the major constraints to efficient okra production. Losses in crop yield due to weed may be greater than those due to other plant pests and diseases (14). Weed control in intercropping system is rather difficult than in sole cropping of the component crops. The major method of weed control in intercropping is manual or mechanical weeding. Okra farmers use hand hoe for most farm operations, including weed control. Timing of weed removal has been shown to be more critical than the frequency of weeding in yam/maize/okra/sweet potato intercrop. According to (14) the critical period of weed interference in the intercrop was between 3 and 16 weeks after planting, Weed interference in the mixture reduced yam tuber yield by 35 %, maize by 60 %, okra 79 % and sweet potato roots by 80 %. They observed that there was no added advantage in keeping the intercrop weed-free throughout the growing season.

Green amaranth (*Amaranthus hybridus*) is one of the vital nutritious vegetable crops commonly intercropped with okra. The crop is mainly planted by broadcasting within the row or on the seed bed. Broadcasting green amaranth within the rows of okra is a procedure whereby the space which otherwise would have been occupied by weeds is replaced by the amaranth. The implication of this is that instead of the farmer wasting his time and resources to control weeds within the rows he would only need to remove the amaranthus and sell to enhance his income.

Till date there is paucity of information on the time of weed removal and cropping system and their effect on weed suppression and crop productivity in okra/amaranthus intercrop.

The objective of this study therefore was to investigate the effect of time of weed removal and cropping system on weed control and crop performance in okra/amaranthus intercrop.

2. MATERIALS AND METHODS

Two field experiments were carried out at the Research Farm of the Federal University of Agriculture, Abeokuta (7°15'N, 3°25'E) in the Forest Savanna Transition agro-ecological zone of South Western Nigeria. The location has a bimodal rainfall distribution pattern which peaks in July and October. (Figure 1) The land had been left fallow for two years after which it was used to cultivate Chochorus and green amaranth. The soil type was a sandy loam with the physical and chemical properties shown in Table 1.

Table 1: Soil Physico-chemical analysis of the experimental plot before planting

Soil property	2011	2012
pH (H ₂ O)	7	6.8
pH (KCl)	6.6	6.3
Organic carbon (%)	1.55	1.24
Total Nitrogen %	0.089	0.094
Organic matter	2.67	2.14
Available P (mg/kg)	21.63	16.44
TEA (cmolKg ⁻¹)	0.3	0.3
Ca (cmolKg ⁻¹)	8	5.6
Mg (cmolKg ⁻¹)	5.2	5.3

K ⁺ (cmolKg ⁻¹)	0.46	0.36
Na (cmolKg ⁻¹)	0.64	0.22
ECEC	14.6	11.78
BS	97.95	98.75
Sand (g/kg)	694	730
Silt (g/kg)	130	124
Clay (g/kg)	176	146
Texture	Sandy loam	Sandy loam

The following weed species were present during the pre-cropping stage at the experimental site; *Talinum triangulare*, *Ageratum conyzoides*, *Spigelia anthelmia*, *Mitracarpus villosus*, *Phyllanthus amarus*, *Euphorbia heterophylla*, *Tridax procumbens*, *Chromolaena odorata*, *Mucuna pruriens*, *Euphorbia herterophyll*, *Panicum maximum*, *Imperata cylindrical*, *Cynodon dactylon*, *Axonopus compressus* and *Cyperus rotundus*.

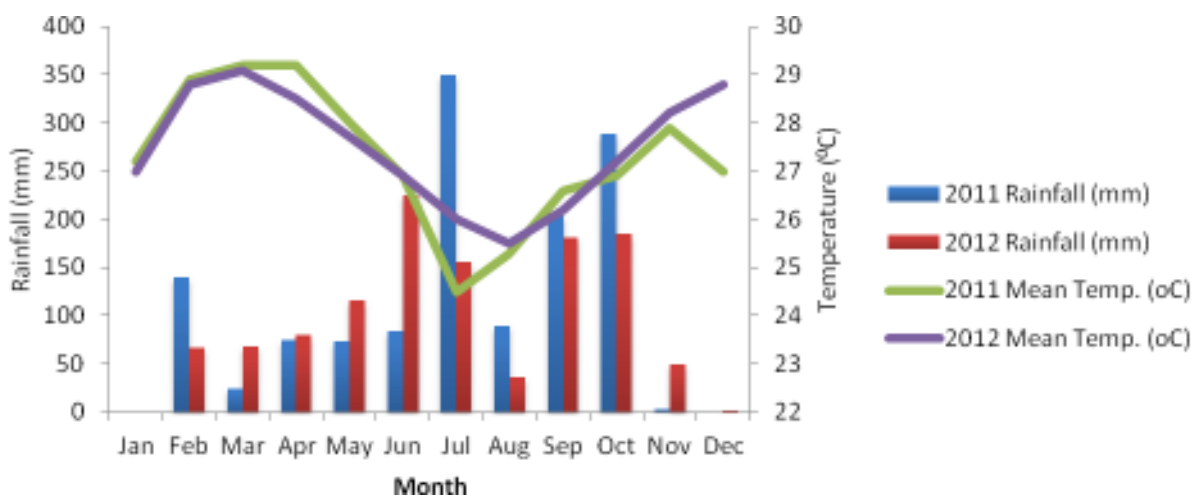


Figure 1: Monthly total rainfall and mean temperature distribution at Alabata in 2011 and 2012

2.1 Experimental Design, Treatments and Plot size

The experiment was laid out in a Randomized Complete Block Design (RCBD) in a Split-plot arrangement which consisted of fifteen treatment combinations replicated three times. The main plot consisted three period of weed removal (WR) namely: single hoe weeding at 3 weeks after planting (WAP), double weeding at 3 & 6 WAP and no weeding while the sub plots which consisted of five cropping system (C) okra intercropped with amaranthus at 0.5 g/m² (P1), or 1.0 g/m² (P 2), sole okra, sole amaranthus at 0.5 g/m² (population1), or 1.0 g/m² (population 2). The gross and net plot sizes were 4m x 4m and 3m x 3m respectively.

Cultural operation

The field was prepared manually using cutlass to remove the established vegetation. Marking out of the field and plot layout was also done while the seed bed was prepared using African hoe. An improved

variety of okra (NHAE-47) and a local variety of green amaranth were obtained from NIHORT (National Horticultural Research Institute, Ibadan, Nigeria). Three seeds of okra were planted at a spacing of 90 cm x 30 cm and later thinned to two plants, at 2 WAP. Weeding operations were carried out as specified above in the treatments. Leaf eating beetles were controlled with cypermethrin at 10 ml/10litres of water.

2.2 Data collection

Data collected from the experiment included the following:

2.2.1 Weed Data

Weed samples were collected at 3, 6 and 9 WAP from three random 0.5 m² quadrat along a diagonal transect in each plot for identification by species, plant taxa and growth form. All weeds within the quadrats were cut at the soil surface and weighed. Weed dry weights were later determined after oven-drying the samples at 70 °C for 48 hours.

2.2.2 Okra growth and Developmental parameters

Okra Height: At 3, 6 and 9 WAP, maximum height of the canopy was measured on five tagged plants in the central row with a meter rule. The average of the five measurements in each plot was recorded.

Days to 50 % flowering and days to 100 % fruiting: Number of days from planting to 50 % flowering was recorded, when half of the plants flowered as well as the number of days when all the plants in each plot podded (100% fruiting).

2.2.3 Yield and yield components of Okra.

Five plants were tagged on each plot and yield and yield components such as number of pods, pod length, pod girth, and fruit yield were determined. The number of fruits was determined by cumulating the number of harvested fruits for each plant. Fruit length was measured with measuring tape from the base of the fruit to the tip while the fruit diameter was taken with a venier caliper 2cm from the base of the fruit. The fruit yield was determined by harvesting the fruits every 3 days.

2.2.4 Amaranthus growth and yield parameters:

Amaranthus height: This was done by measuring from the base to the tip of five tagged plants at 3 and 6 WAP.

Fresh weight at harvest: At harvest, fresh weight of amaranthus in the net plot was taken.

2.2.5 The Land Equivalent Ratio (LER)

The Land Equivalent Ratio (LER) was calculated using the formula described by (15).

$$\frac{\text{Yield of Intercropped X}}{\text{Yield of Sole X}} + \frac{\text{Yield of Intercropped Y}}{\text{Yield of Sole Y}}$$

Where X = Okra and Y = Amaranthus. The LER was calculated to determine the relative advantage of intercropping over sole cropping.

The data collected were subjected to analysis of variance (ANOVA) and treatment means were compared using Fisher's Protected Least Significant Difference (LSD) at $P < 0.05$.

3. RESULTS

3.1 Effects of treatments on weed specie composition and weed dry weight in Okra/Amaranthus intercrop.

In 2011, the most dominant weed species were *Ageratum conyzoides*, *Tridax procumbens*, *Euphorbia heterophylla* and *Panicum maximum* while in 2012, *Ageratum conyzoides*, *Tridax procumbens*, *Talinum triangulare*, *Axonopus compressus* had the highest weed intensity (Table 2). The weed control treatments had significant effect ($p < 0.05$) on weed dry weight at 3, 6 and 9 WAP (Table 3). There was increasing weed biomass as the season progresses in plots where weeds were left uncontrolled. Single (3 WAP) and double (3 and 6 WAP) weeded plots maintained a relatively constant weed biomass throughout the period of observation. The study also showed that there was no significant difference among the weed biomass in the pure stands of okra and amaranthus as well as their mixtures (Table 3). Interaction between the time of weed removal and plant population on weed dry weight was not significant.

3.2 Effects of treatments on growth and yield of okra in Okra/Amaranthus intercrop

Weed control treatments had no significant effect on height of okra at 3 and 6 WAP (Table 4); also, days to flowering and dry matter production (Table 5). Interaction between the time of weed removal and plant cropping system of amaranthus on the growth of Okra was also not significant.

3.3 Effects of treatments on yield and yield components of okra in Okra/Amaranthus intercrop

Results from this study showed that pod length and fruit yield were significantly ($p < 0.005$) affected by the time of weed removal (Table 6). Weed removal at 3 WAP compared favourably well with maximum values obtained from weeding at 3 and 6 WAP period. The double weeding at 3 & 6 WAP plots and plot weeded 3 WAP gave 5.16 and 4.77 t/ha fruit yield respectively in 2011 while in 2012, double weeding at 3 & 6 WAP plots and plot weeded at 3 WAP only gave 2.92 and 2.80 t/ha fruit yield respectively. It was also observed that cropping system had no significant ($p > 0.05$) effect on the fruit length, diameter, and fruit yield irrespective of the year of planting (Table 6).

3.4 Effects of treatments growth and yield of amaranthus in Okra/Amaranthus.

The effects of time of weed removal and cropping system on plant height, fresh and dry weight of amaranthus are presented on Table 7. The results indicate that time of weed removal and cropping system had no significant ($p < 0.05$) effect on plant height and fresh weight of amaranthus. Furthermore, the interactions between the time of weed removal and plant cropping system on plant height and yield of amaranthus were not significant either.

3.5 Intercrop Productivity:

The study showed that intercropping had advantage over sole crop. The Land equivalent (LER) of the okra/amaranthus intercrop population 1 and population 2 were 1.93 and 1.50 respectively.

4. DISCUSSION

In this study, comparable maximum fruit yield was obtained in plots where weeds were controlled through single (3 WAP) and double (3 and 6 WAP) weeding and plots weeded 3 WAP. Uncontrolled weed infestation led to 50.7 % yield loss in okra fruit yield while weed removal at 3 WAP only resulted in 5.2% yield reduction. In these treatments there were corresponding decreases in weed biomass (Table 2). Okra and amaranthus were observed to have higher canopy than the weeds. (16) observed that the most important feature of plants that determine their competitive ability for light is height. They reported

that a successful competitor for light is the component that has its foliage at a higher canopy layer. (17) also reported that in an intercropping situation, the taller component crop intercepted the major share of light such that the growth rates of the two crops would be proportional to the quantity of the photosynthetic active radiation they intercepted.

Fruit yield obtained in 2011 was generally higher than 2012. This could be attributed to cessation of rain at the reproductive stage of the crops in 2012. This reduction in yield can be traced back to reduced growth height of the crop (okra). The height of okra plants in 2011 almost doubled that of 2012 (Table 4). It was also observed that the yield of each component crop was higher at higher amaranth plant population (1.0g/m^2). Amaranth through competition would have provided an environment of reduced weed biomass for okra. Several authors (8); (11); (18) have reported that weed suppression was stronger in intercrop than in monocultural components and at higher plant population.

This study showed that weed biomass increased with time in the weed infested plot while the rate of increase was constant in the single and double weeding reduced weeds which resulted in increased yield and yield components of okra. The values obtained from the Land Equivalent ratios (LER), there was yield advantage of intercropping okra with amaranthus. In this situation intercropping okra with amaranthus at 0.5 g/m^2 and 1.0 g/m^2 would have required 93 % and 50 % more land if planted in sole stands of okra and amaranthus respectively. This result agrees with the findings of (8) who worked on the biological efficiency of intercropping okra with amaranthus. Their finding showed that the LER was greater than unity for wider and closer spacing (1.77 and 1.91) respectively.

5. CONCLUSION AND IMPLICATIONS OF THE STUDY

Crop density is probably one of the most easily manipulated factors affecting crop production and is well known that increasing seeding rates can enhance crop dominance over weeds in monoculture cropping system. This study showed that intercropping of okra and amaranthus could be a veritable way of reducing weed pressure in okra/amaranth intercrop as well as increasing land productivity. At high density of amaranthus (1.0g/m^2), and single- timed weed removal at 3 WAP, growth and optimum fruit yield of okra and amaranthus will still be sustained. However, the result of this study is at variance with the findings of (6) who reported that it was better to grow okra and vegetable amaranth separately especially at higher amaranth planting density because there was yield disadvantage when they were in mixtures.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Table 2: Pre-cropping Weed specie composition of the experimental site in 2011 and 2012

Weed specie	Family	Growth form	2011	2012
<i>Ageratum conyzoides</i>	Asteraceae	ABL	+++	+++
<i>Mucuna pruriens</i>	Leguminosae	PBL	+	-
<i>Tridax procumbens</i>	Asteraceae	ABL	+++	+++
<i>Spigelia anthelmia</i>	Loganiaceae	ABL	++	++
<i>Mitracarpus villosus</i>	Rubiaceae	ABL	++	-
<i>Phyllanthus amarus</i>	Euphorbiaceae	ABL	+	-
<i>Euphorbia heterophylla</i>	Euphorbiaceae	ABL	+++	++
<i>Chromolaena odorata</i>	Asteraceae	ABL	++	++
<i>Talinum triangulare</i>	Portulacaceae	ABL	++	+++
<i>Panicum maximum</i>	Poaceae	PG	+++	++
<i>Axonopus compressus</i>	Poaceae	AG	++	+++
<i>Imperata cylindrical</i>	Poaceae	PG	++	+
<i>Cyperus rotundus</i>	Cyperaceae	PS	++	+

+= Low intensity, ++= moderate intensity+++=high intensity, ABL= Annual Broadleaf, PG=Perennial Grass, PS=Perennial Sedges

Table 3: Effect of time of time of weed removal and cropping system on weed biomass in okra/amaranthus intercrop in 2012

Treatment	Weed dry weight (g/m ²)			Mean Weed Dry Weight (g/m ²)
	3WAP	6WAP	9WAP	
Time of Weed Removal (W)				
No weeding	73.2	137.6	197.9	136.3
Double weeding at 3 & 6 WAP	15.9	16.7	16.0	16.87
Single weeding at 3 WAP	61.1	62.6	61.9	61.9
SED	6.61	12.7	16.7	29.2
LSD (0.05)	18.37*	35.31*	46.3**	81.3*
Cropping Pattern (C)				

Okra Sole	48.1	78.5	101.7	76.10
Sole amaranthus P1	52.8	73.9	92.4	73.03
Sole amaranthus P2	52.0	73.0	90.3	71.77
Okra+Amaranthus P1	49.2	72.3	89.5	70.33
Okra +Amaranthus P2	48.3	63.6	85.6	65.83
SED	4.4	7.0	7.3	3.02
LSD (0.05)	ns	ns	ns	ns
Interaction (WXC)				
SED	9.5	14.2	15.1	6.24
LSD (0.05)	ns	ns	ns	Ns

270 WAP= Weeks after planting, ns=not significant, *=significant at 0.05, **=significant at 0.001, P1= amaranthus at 0.5 g/m², P2= amaranthus at 1.0 g/m²

272 **Table 4: Effect of time of weed removal and cropping system on Plant Height of okra in**
273 **okra/amaranthus intercrop in 2011 and 2012 wet seasons**

Treatment	Plant Height (cm)			
	3WAP		6WAP	
	2011	2012	2011	2012
Time of weed Removal (W)				
No weeding	34.09	9.80,	32.42	15.70
Double Weeding at 3 and 6 WAP	34.26	9.80	32.65	18.10
Single weeding at 3 WAP	36.80	8.70	35.73	13.60
SED	2.30	0.75	2.38	2.61
LSD (0.05)	ns	Ns	ns	Ns
Cropping System(C)				
Okra Sole	35.73	9.18	34.17	17.50
Okra+Amaranthus P1	35.28	10.10	33.48	14.60
Okra +Amaranthus P2	31.14	9.71	33.15	15.3
SED	2.30	0.75	2.38	2.61
LSD (0.05)	ns	ns	ns	Ns
Interaction (WXC)				
SED	3.99	2.00	4.12	4.51
LSD (0.05)	ns	ns	ns	Ns

274 WAP= Weeks after planting, ns=not significant, P1= amaranthus at 0.5g/m², P2= amaranthus at
275 1.0g/m²

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284 **Table 5: Effect of time of weed removal and cropping system on plant height, days to 50%**
285 **flowering and days to 100% fruiting of okra in okra/amaranthus intercrop in 2012**

Treatment	Plant Height (cm)		Days to 50% flowering	Days to 100% Fruiting
	3WAP	6WAP		
Weedy removal (W)				
No weeding	34.09	32.42	24.00	46.90
Double Weeding at 3 and 6WAP	34.26	32.65	28.60	52.70
Single weeding at 3 WAP	36.80	35.73	27.10	52.10
SED	2.30	2.38	2.84	5.51
LSD (0.05)	ns	ns	ns	ns
Cropping System (C)				
Sole okra	35.73	34.17	28.00	52.60
Okra+ Amaranthus P1	35.28	33.48	27.60	47.00
Okra+ Amaranthus P2	31.14	33.15	24.10	52.10
SED	2.30	2.38	2.84	5.51
LSD(0.05)	6.30*	6.62*	7.89*	15.31*

Interaction SED (WxC)	3.99	4.12	9.33	9.55
LSD(0.05)	ns	ns	ns	ns

286 WAP= Weeks after planting, ns=not significant, P1= amaranthus at 0.5 g/m², P2= amaranthus at 1.0
287 g/m²

288 **Table 6: Effect of time of weed removal and plant population on fruit length, number of fruits and**
289 **fruit weight of okra/amaranthus intercrop in 2011 and 2012 wet seasons**

Treatment	<u>Fruit Length (cm)</u>		<u>Fruit Diameter Girth (cm)</u>		<u>Number of Fruits/plant</u>		<u>Fruit weight (t/ha)</u>	
	2011	2012	2011	2012	2011	2012	2011	2012
Time of weed Removal (W)								
No weeding	4.50	2.45a	4.11	1.91	9.89	4.44	2.48a	1.50a
Double Weeding at 3 and 6 WAP	4.61	3.04b	4.41	2.36	11.02	7.33	5.16b	2.92b
Single weeding at 3 WAP	4.55	3.19b	4.16	2.36	10.67	6.33	4.77b	2.80b
SED	0.38	0.18	0.31	0.18	0.85	0.29**	0.85	0.44
LSD (0.05)	ns	0.05*	ns	ns	ns	0.81**	2.36*	1.22*
Cropping System (C)								
Okra Sole	4.69	2.93	4.36	2.18	11.00	5.67	4.27	2.46
Okra+Amaranthus P1	4.33	3.04	4.07	2.23	10.11	6.33	4.17	2.35
Okra +Amaranthus P2	4.55	2.81	4.26	2.28	10.67	6.11	3.98	2.44
SED	0.38	0.18	0.38	0.05	0.85	0.38	0.36	0.07
LSD (0.05)	ns	ns	ns	ns	ns	ns	ns	ns
Interaction (WXC)								
SED	0.66	0.31	0.54	0.19	1.48	0.61	0.62	0.46
LSD (0.05)	ns	ns	ns	ns	ns	ns	ns	ns

290 WAP= Weeks after planting, ns=not significant, *=significant at 0.05, **=significant at 0.001,, P1=
291 amaranthus at 0.5 g/m², P2= amaranthus at 1.0 g/m²

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293 Figures followed by the same alphabets in a column are not significantly different by LSD test at 5%
294 probability.

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296 **Table 7: Effect of time of weed removal and plant population on growth and yield characteristics**
297 **of amaranthus in okra/amaranthus intercrop in 2012**

Treatment	Plant Height (cm)			Fresh Weight at Harvest (t/ha)	Dry matter(t/ha)
	3WAP	6 WAP	9 WAP		
Time of weed Removal (W)					
No weeding	16.72	28.3	41.3	2.49	1.24
Double Weeding at 3 and 6 WAP	19.18	34.8	56.4	5.62	2.43
Single weeding at 3 WAP	16.12	38.6	50.9	3.17	1.63
SED	2.32	3.83	5.83	0.98	0.73
LSD (0.05)	ns	ns	2.72*	ns	ns
Cropping System(C)					
Sole amaranthus (P1)	16.57	34.00	42.4	3.65	1.88
Sole amaranthus (P2)	19.00	34.80	52.3	5.18	2.15
Okra+Amaranthus P1	16.59	31.7	50.1	3.56	1.21
Okra +Amaranthus P2	17.36	35.1	47.2	2.64	1.80
SED	1.95	4.23	5.97	1.23	0.55
LSD (0.05)	ns	ns	ns	ns	ns
Interaction (WXC)					
SED	3.69	7.41	10.68	2.09	1.10
LSD (0.05)	ns	ns	ns	ns	ns

WAP= Weeks after planting, ns=not significant, P1= amaranthus at 0.5 g/m², P2= amaranthus at 1.0 g/m²